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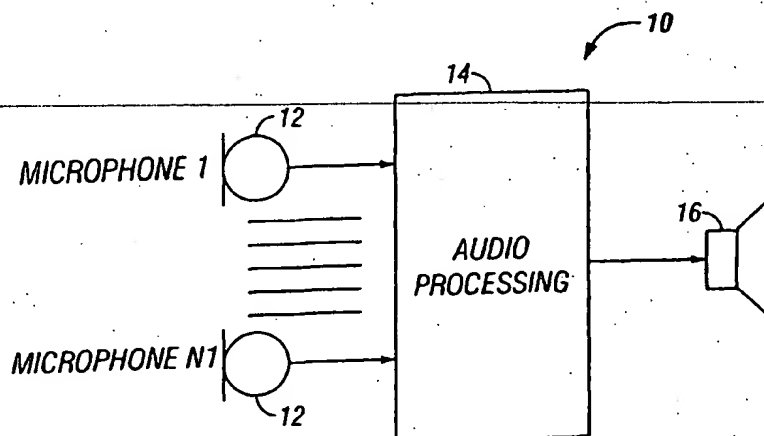
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SOUND PROCESSING SYSTEM INCLUDING WAVE GENERATOR THAT EXHIBITS ARBITRARY DIRECTIVITY AND GRADIENT RESPONSE



(57) Abstract: A sound processing system including at least one microphone, an audio processor, and at least one output device. The audio processor includes an analog beamformer, a microphone equalizer, and an apparent incidence processor. Two different embodiments of the apparent incidence processor are disclosed, that is, a wave generation method and a forward filtering method. Both embodiments use the same principles to estimate the properties of the individual waves of the sound field. With the present invention, it is possible to implement arbitrary directivity responses using a small number of microphones only, that is, two or three microphones. The present invention offers improved noise reduction also for environments with many independent noise sources. Furthermore, the present invention works for signals and noises with arbitrary statistics.

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INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 02/09031

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04R3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 023 514 A (STRANDBERG MALCOLM W P) 8 February 2000 (2000-02-08) column 4, line 46 -column 9, line 6 column 10, line 14 -column 13, line 36; figures 1,2,4A-4C	1-4, 15, 17-19, 21, 41-44, 68-71, 73, 79
A	US 5 978 490 A (CHOI HYUN-WOO ET AL) 2 November 1999 (1999-11-02) column 3, line 30 -column 6, line 5; figures 5-9 -/-	1, 41



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

S document member of the same patent family

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, A	US 6 317 703 B1 (LINSKER RALPH) 13 November 2001 (2001-11-13) column 3, line 6 -column 4, line 31; figures 1,2	1,41
A	EP 0 831 458 A (NIPPON TELEGRAPH & TELEPHONE) 25 March 1998 (1998-03-25) page 9, line 56 -page 15, line 41; figures 11-16	40,82

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP 02/09031

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

1-4, 15, 17-19, 21, 40-44, 68-71, 73, 79, 82

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4, 15, 17-19, 21, 41-44, 68-71, 73 and 79

Independent claim 1 relates to an audio processor for a sound processing system comprising a plurality of microphones and an output device, wherein the system senses a sound environment in at least a first frequency band and the sound environment has at least a first wave parameter, the audio processor comprising:

- an apparent incidence processor (22) that employs a wave generation method, the apparent incidence processor (22) comprising:
 - a wave parameter estimator (54) connected to the input of the apparent incidence processor, wherein the wave parameter estimator (54) generates a set of estimates of wave parameters for the at least a first frequency band of the input signals characterizing the at least one wave; and
 - a first output generator (56) connected to the output of the wave parameter estimator (54), wherein the first output generator (56) produces a first output signal that contains at least one wave generated according to the at least a first set of wave parameter estimates.

Independent claim 40 relates to a method of audio signal processing corresponding to claim 1, respectively.

1.1. Claims: 2-4, 42-44

Apparatus claim 2, which depends on independent claim 1, further specifies that the audio processor comprises:

- a microphone equalizer (20) connected to the input of the audio processor;

Claim 42, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 2.

1.2. Claim : 15 and 68

Apparatus claim 15, which depends on independent claim 1, further specifies that the apparent incidence processor (22) further comprises a second output generator (56) connected to the output of the wave parameter estimator (54).

Claim 68, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 15.

1.3. Claims: 17-19 and 69-71

Apparatus claim 17, which depends on independent claim 1, further specifies that the wave parameter estimator (54) comprises at least a first analysis filter (62) connected to at least a first microphone, which at least a first analysis filter (62) creates an input signal in addition to the input signals characterizing the at least one wave.

Claim 69, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 17.

1.4. Claim : 21 and 73

Apparatus claim 21, which depends on independent claim 1, further specifies that the wave parameter estimator (54) disregards the amplitude information of the input signals during the generation of a wave direction estimate.

Claim 73, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 21.

1.5. Claim : 79

Method claim 79, which depends on independent claim 41, further specifies that the estimated parameter is the direction of sound incidence.

2. Claim : 5 and 45

Apparatus claim 5, which depends on independent claim 1, further specifies that the audio processor comprises:

- an analog beamformer (18) connected to the input of the audio processor and preprocessing the input signals;
- at least 2 A/D converters having different resolutions and being connected to the output of the analog beamformer (18) and to the input of the apparent incidence processor.

Claim 45, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 5.

3. Claim : 6 and 46

Apparatus claim 6, which depends on independent claim 1, further specifies that the apparent incidence processor comprises:

- an analysis beamformer (52) connected to the input of the apparent incidence processor (22) and an output connected to the input of the wave parameter estimator (54), the analysis beamformer (52) filtering the input signals and generating a plurality of output signals, whereby for each

output signal the analysis beamformer (22) includes a plurality of filters (58) connected to a summer (60)

Claim 46, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 6.

4. Claims: 7-10, 20, 22-25, 47-50, 72, and 74-76

Apparatus claims 7-10 and 20, which depend on independent claim 1, further specifies that:

- the wave parameter estimator (54) comprises:
 - an equation solver (68) which performs:
- an iteration technique (claims 7, 22),
- a parameter scan technique (claim 8),
- a minimal power technique (claim 9),
- employs a look-up table (claims 10, 25), or
- a direct solving technique (claim 20);
 - or which operates in
- the frequency domain (claim 23), or
- the time domain (claim 24)

Claims 47 and 74, 48, 49, 50 and 72, which each depend on independent claim 41, relate to a method of audio signal processing corresponding to claims 7-10 and 20, respectively.

Claims 75 and 76, which each depend on independent claim 41, relate to a method of audio signal processing corresponding to claims 23 and 24, respectively.

5. Claims: 11-14

Apparatus claim 11, which depends on independent claim 1, further specifies that the output generator (56) comprises:

- a statistical evaluator (92) analyzing the waves to obtain measures of the running signals and noise powers of the sound field.

6. Claim : 16

Apparatus claim 16, which depends on independent claim 1, further specifies that a wide band power of the waves in the sound field are measured and that the first output generator amplifies waves originating from a range of directions centered around the origin of the wave with the largest power.

7. Claims: 26-39 and 51-67

Apparatus claim 26, which depends on independent claim 1, further specifies that the first output generator (56) comprises

- a wave generation gain controller (94),
- and a signal generator (100),

wherein the wave generation gain controller (94) analyses the at least one wave and attaches a gain to the at least a first frequency band of the at least one wave and the signal generator (100) applies the gain to the at least one wave.

Claim 51, which depends on independent claim 41, relates to a method of audio signal processing corresponding to claim 26.

8. Claim : 40 and 82

Independent apparatus claim 40 corresponds generally to independent apparatus claim 1, with the additional provision of a forward filter (136) connected to the input of the apparent incidence processor (22) and to the output of the wave parameter estimator (54), and filtering the input signal according to the wave parameter estimates.

9. Claims: 77, 78 and 80

Claims 77, 78 and 80, which each depend on independent claim 41, further specify that the first set of wave parameter estimates is:

- a wave frequency estimate (claim 77)
- a wave amplitude estimate (claim 78), or
- a wave damping estimate (claim 80)

10. Claim : 81

Method claim 81, which depends on independent claim 41, further specifies that the at least a first set of wave parameter estimates is compared with a predetermined value.

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 02/09031

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6023514	A	08-02-2000	EP 1057291 A1 JP 2001527317 T WO 9933201 A1	06-12-2000 25-12-2001 01-07-1999
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